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REMARKS.

1. The average inclination of the first hundred (in the order of distance) is..... $8^{\circ} \ 8' \ 42.66''$
 Of the second hundred..... $8 \ 58 \ 33.87$
 Of the last eighty..... $7 \ 51 \ 20.15$
 And that of the whole two hundred and eighty. $8 \ 21 \ 34.87$
2. The inclinations in the edges of the ring are less than the average.
3. Other *minima* are found about the distances 2.44 and 3.09. The *maximum* between 2.36 and 2.40 is distinctly marked.
4. As in the case of other planets, the inclinations vary, though with extreme slowness. It has not been shown, however, that the *average* will change to any great extent.
5. This average compares thus with certain other inclinations :
 Mercury's orbit $7^{\circ} \ 00'$
 Plane of the Sun's equator..... $7 \ 15$
 Average inclination of asteroidal comets..... $16 \ 40$
6. The *maximum* inclinations of Mercury and Mars are $10^{\circ} \ 36'$ and $7^{\circ} \ 28'$ * respectively. The table indicates that the *mean inclination* of the asteroids has not differed greatly from the mean inclination of Mercury.

A Review of the North American Species of Hippotherium.

By E. D. Cope.

(Read before the American Philosophical Society, May 3, 1889.)

The relation of this genus to the other genera of Perissodactyla was indicated by Kowalewsky in his work on the genus Anthracotherium, published in the "Palæontographica" for 1874. He there showed that the genus occupies a place between Anchitherium and Equus in the genealogical phylum, as it does in geological time. In a paper on the "Systematic Arrangement of the Perissodactyla,"† the present writer placed Hippotherium in the family Palæotheriidae, in a subfamily Hippotheriinae, which was defined as follows: "Bicipital groove of humerus double; molars with cement in the valleys." This subfamily embraces the genera Hippotherium Kaup, and Protohippus Leidy. The Palæotheriidae is here only distinguished as a whole from the Equidae by the presence of perfect second and fifth digits.

The place of Hippotherium in the line of ancestry of the genus Equus

* Stockwell's Mem. on the Sec. Var. of the El. of the Eight Princ. Planets, Smith. Contrib. to Knowl., 232, p. 116.

† Proceedings American Philos. Soc., 1881, p. 399.

has been admitted by Kowalewsky, Huxley, Marsh and the writer. I have pointed out* that it is probable that the ancestry of some of the species of *Equus* can be traced to *Hippidium*, and therefore to *Protohippus*, as well as to *Hippotherium*, thus showing a diphyletic ancestry of the true horses. Mlle. Marie Pavlov† has devoted some care to the attempt to demonstrate that the latter genus could not have entered into this line. Her objections are derived from a consideration of the characters of the feet. Until however we know the structure of the feet in species of *Hippotherium* other than the *H. primigenium* of Europe, we cannot be positive as to the relation of particular species of that genus to particular species of *Equus*.

HIPPOTHERIUM Kaup.

Jahrbuch für Mineralogie, etc., 1833, 327 (description). *Nova Acta Leop.* 1835, xviii, 171–182. *Jahrbuch f. Mineralogie*, 1835, 622. *Bronn Lethæa Geognostica*, 1853–6, iii, p. 876.

Hipparion Christol. “*Annales science d. Midi*, 1832, March, May,” name only, fide Bronn. “*These sur les Brèches Osseuses*, 1834, 26; *Annales des Sciences Naturelles*, 1835 *b*, v, 193,” name only, fide Bronn.

Anterior interior column (protocone) of the superior molars distinct from the anterior interior crescent, hence giving an isolated dentinal area on attrition. Second and fifth digits present on both limbs, and of reduced size. Bicipital groove of humerus double. Metapodials without trochlear keel on the anterior face; third metatarsal without entocuneiform facet.

The preceding characters define a genus which had a general distribution over the Northern hemisphere during late Miocene and Pliocene time. It embraces a number of species, which were evidently present in droves in the countries where their remains are now found.

This genus and *Protohippus* include the latest representatives of the three toed horses, the lateral digits being reduced to small proportions. These genera represent also two types of dentition easily modifiable into *Equus* by slight alterations in the relations of the internal columns of the superior molars. In *Hippotherium* the coalescence of the internal columns has not been accomplished, for one of them remains in the isolated position of the internal cone of the symborodont type of dentition. In the species of the *H. occidentale* type, the anterior column is larger than the posterior, displaying considerable increase in the anteroposterior diameter. This is the character of the same column in *Equus*, and the junction of the column with the adjacent crescent is all that is necessary to convert the one genus into the other, so far as the superior molars are con-

* *American Naturalist*, 1887, p. 1075.

† *Etudes sur l'Histoire Palæontologique des Ongulés*; II. Le Development des Equidæ, Moscow, 1888.

cerned. In *Protohippus*, on the other hand, the junction has already taken place, but as the columns are of equal size, the pattern resulting is different from that of *Equus*. It is that of *Hippidium*, which, like *Equus*, has but one digit. An approach to *Hippidium* is seen in the species of Group II of the analytical table below, to one of which I gave the name of *Stylonus*. In this type the internal columns are of subequal proportions as in that genus. The posterior is joined to the corresponding internal crescent, and though the anterior column approaches very near to the anterior internal crescent by an apex of its section, it never does actually join. On the other hand, the posterior column is distinct in the just-protruded molar, and in the *H. seversum* remains distinct for a considerable part of the age of the animal.

The genus *Hippodactylus** Cope, has the molar teeth of the general character of *Hippotherium*, but it possesses, like *Hippidium*, but one digit. The type is the *H. antelopinum* Falconer, of the Sivalik Upper Miocene of India. I think it not unlikely that when the skeletons of some of the species here referred to *Hippotherium* come to be known, that some of them will be found to belong to *Hippodactylus*.

History.—This genus was named by Christol and Kaup within about a year of each other, according to Bronn. I have not been able to refer to the essay in which the earliest name, that of Christol, was published, but according to Bronn, it was not accompanied by any generic description. In Kaup's first publication an attempt is made to characterize the genus, and although the description contains some errors, the important fact of its possessing dew-claws is mentioned. Two years later Kaup published a fuller and more accurate diagnosis. Christol does not appear to have ever given a description of the genus. The use of his name (*Hipparion*) does not therefore appear to be warranted.

Species.—The type is *Hippotherium primigenium*, the *Equus primigenius* of Von Meyer and the later *H. gracile* of Kaup. Its remains are common in the Mediterranean countries of Europe, and in France. A few other species have been discovered in the Old World. Their history has been elucidated by Wagner, Duvernoy, Gervais and others. North America has furnished a larger number of specific forms than any other country.

The American species of *Hippotherium* differ in the extent of the pre-orbital facial depression. In *H. speciosum* as in *H. primigenium*, the fossa is confined to the superior part of the facial region; in *H. isonesum* it extends downwards to the molar ridge, as in certain species of *Protohippus*.

The teeth of this genus are most frequently found in a well-preserved condition, and are hence most useful for purposes of determination. The species may be ascertained from those of the maxillary bone, though not without some difficulty. This is rather due to differences between the teeth of the same series than to the variability of the characters them-

* American Naturalist, 1888, p. 449.

selves. In the species successive modifications may be traced from the equine form of the genus represented by *H. occidentale* to that which approximates the genus *Protohippus*, represented by *H. seversum*. In the former the anterior interior column is larger than the posterior, forms a more prominent rib on the inner face of the crown of the tooth, and is flattened or even concave on the inner side. After this form come others where the anterior column is round, and then others where it presents a ridge towards the anterior inner crescent, which in the worn section forms an apex or angle of the outline. The succeeding forms have the two inner columns of equal diameter and prominence, and though the anterior one maintains its distinctness its section projects in an angle towards the adjacent crescent. Finally we have the form where the subequal columns are both separated from their adjacent crescents, forming the supposed genus *Stylonus* Cope.

The internal columns in all the species become most longitudinally compressed in the posterior superior molars. The enamel borders of the lakes are frequently less complex in these teeth. In all the molars the apices of the crescents and columns are narrower in earlier than in later stages of wear, and the posterior inner column is sometimes separate for a short time. The enamel borders of the lakes become more complex also on wear, till middle age; they then, on further wear, become more simple.

In the following analytical table the characters of the fifteen species known to me from North American formations are set forth :

I. Anterior internal column of superior molars more prominent inwards than the posterior, larger, and not approaching union with the anterior internal crescent. *Hippotherium* Kaup.

A. Section of anterior internal column concave or flat on the internal side. Crowns prismatic.

a. Lake borders very complex; the loop nearly or quite isolated.

Grinding surface subquadrate; crown straight; larger; crown 25 mm. long; 24 mm. wide.....*H. occidentale*.

Like the last; smaller; grinding face 22 by 21 mm.....*H. montezumæ*.
Grinding surface oblong, 19 by 16 mm.; crown curved..*H. peninsulatum*.

aa. Lake borders simple; loop simple, open.

Grinding surface oblong, 22 by 19 mm.; crown nearly straight

H. sinclairii.

AA. Section of anterior internal column oval.

a. Internal columns wide apart.

Grinding face subquadrate, 20 by 19 mm.; lakes of medium complexity.....*H. speciosum*.

Like the last, but lake borders highly complex.....*H. plicatile*.

Grinding face oblong, 22 by 21 mm.; lakes of medium complexity; column apiculate as in sect. *Stylonus*; p. m. iii elongate..*H. sphenodus*.

Grinding face oblong, smaller, 19 by 17 mm.; lakes of medium complexity; column entire.....*H. gratum*.

aa. Anterior internal column joining the posterior internal column.

Grinding face oblong, 20 by 17 mm. ; lakes rather complex, with a large loop.....*H. retrusum*.

AAA. Section of anterior internal column round.

Larger ; grinding face square, 19 by 20 mm. ; complexity medium ; posterior column not so prominent inwards.....*H. paniense*.

Smaller ; grinding face longitudinal, 19 by 17 mm. ; lakes complex ; posterior internal column not prominent.....*H. venustum*.

Smaller ; grinding face transverse, 16 by 19 mm. ; posterior inner column nearly as prominent as anterior inner.....*H. relictum*.

II. Posterior internal column as prominent inwards and of nearly equal size with the anterior, and nearly cut off from the posterior inner crescent. Anterior inner column with an apex directed towards the anterior inner crescent. *Stylonus* Cope.

Large ; grinding face 24 by 23 mm. ; largest premolar short, wide
H. calamarium.

Smaller ; grinding face 20 by 18 mm. ; largest premolar elongate, wedge-shaped.....*H. isonesum*.

Smallest ; grinding face 17 by 17 mm. ; lake borders simple..*H. seversum*.

The stratigraphic position of these species is as follows :

Lower Pliocene.

H. relictum Cope.

? *H. venustum* Leidy.

Ticholeptus bed.

H. seversum Cope.

H. isonesum Cope.

Loup Fork (Upper Miocene).

H. calamarium Cope.

H. paniense Cope.

H. retrusum Cope.

H. gratum Leidy.

H. sphenodus Cope.

H. plicatile Leidy (? horizon).

H. speciosum Leidy.

H. sinclairii Wortman (? horizon).

H. peninsulatum Cope.

H. montezumæ Leidy.

H. occidentale Leidy.

Of the preceding fourteen species I have seen teeth of all but the *H. venustum* of Leidy, which was found in the South Carolina phosphate beds. I have parts of several individuals of the *H. gratum* from Kansas, and the *H. retrusum* is from the same locality. *H. plicatile* is from Florida, and the *H. peninsulatum* and *H. montezumæ* are from Eastern Mexico. I have

but one molar each of *H. occidentale* and *H. sinclairii*, both from Cottonwood creek, Oregon. *H. speciosum* is the most abundant and widely distributed species; Leidy reporting it from Dakota, Nebraska and Texas, and its occurrence in New Mexico being recorded in my report to Lieut. Wheeler. Mr. Hill has since obtained fine specimens in Kansas. The *H. paniense* is known from a few teeth obtained by myself in Northeastern Colorado. The *H. calamarium* I found to be the predominating species in the Loup Fork beds near Santa Fé, New Mexico, and it is not rare in Northeastern Colorado. *H. isonesum* was apparently common in the Northwest, two fine specimens having been found by Mr. Wortman on the Cottonwood creek, Oregon, and one or more on the Deep river, Montana, by Mr. J. C. Isaac. *H. seversum* is so far only known from an Oregon specimen. The *H. relictum* has been so far also only found in Oregon.

HIPPOTHERIUM OCCIDENTALE Leidy.

Proceed. Academy Philada., 1858, 27. *Hipparion occidentale* Leidy, Proceed. Academy Phila., 1856, 59. Extinct Mammalia Dakota Nebraska, 1869, 281, 326, Pl. xviii, Figs. 1-5; xxvii, Fig. 2.

Known to me from a single superior molar tooth of the left side, found by Mr. Wortman on Cottonwood creek in Eastern Oregon.

The crown is very long, and almost rootless, and the cement layer is quite thick, especially towards the distal portion of the crown. The inner anterior column is flattened, and occupies a middle part of the fore and aft diameter of the crown. It is slightly crescentoid in section, and presents its anterior apex slightly inwards. The posterior inner lobe is not cut off from the inner crescent by any contraction. The lakes have their inner portions very prominent and marked off from the external portion by deep inflections of the border. There are two posterior and two interior inflections of the anterior crescent, and the adjacent ones of the two pairs nearly cut off a large loop, which thus occupies the centre of the crown. The posterior lake has two anterior and no interior inflections.

Measurements.

	M.
Length of crown.....	.056
Diameters of crown { anteroposterior.....	.024
{ transverse.....	.024

I suspect that the *Hippotherium affine* Leidy (Extinct Mammalia, Dakota and Nebraska, p. 286) is based on young individuals or represents a slight variety of this species.

HIPPOTHERIUM SINCLAIRII Wortman.

Revue Scientifique, Paris, 1883, p. 712.

I know a single left superior molar of this species. It is easily distinguished from the corresponding tooth of *H. occidentale* by its inferior size

and relatively smaller transverse diameter. Its dimensions are about those of the *H. speciosum*, but it differs from that species in the larger and flatter inner column, longer crown, and less complex folds of the borders of the lakes.

The crown is long and nearly straight, as in *H. occidentale*. In its present condition there is but little external cementum, which may be a result of weathering, nevertheless that which remains in the grooves of the inner side does not form a thick layer. The outlines of the lakes are not extended inwards as in *H. occidentale*, and the transverse diameter of the latter is relatively small. The anterior lake has one posterior inflection, one interior and one anterior; of the posterior lake there are two anterior, none interior and one posterior; a short loop extends towards the inner column area. The latter is convex on the outer side, and without trace of angle or apex.

Measurements.

	M.
Length of crown.....	.043
Diameters of crown { anteroposterior.....	.021
{ transverse .....	.019

Discovered by J. L. Wortman on Cottonwood creek, Eastern Oregon.

HIPPOTHERIUM MONTEZUMÆ Leidy.

Proceedings Academy Philadelphia, 1882, p. 297. *H. rectidens* Cope, Proceedings American Philosophical Society, 1886, p. 360.

This species is known from two superior molar teeth, one of which is in the possession of Dr. Joseph Leidy, and the other is in my private cabinet. It is nearly allied to the *H. occidentale*, but is smaller, and the enamel borders of the lakes are rather more complex. The internal column is longitudinal in section, and the internal face is slightly concave. The posterior column is quite small, and is well defined from the posterior inner crescent by a deep posterior sinus. Two strong loops project towards the internal column from the adjacent enamel border. The lakes have a deep emargination on each of their distant enamel borders, and a number of loops on their approximated borders. One of these, which represents the largest excurrent loop of other species, is of unusual size and prominence, and is nearly isolated by the constriction of its isthmus. In my specimen it is touched by the apex of an excurrent loop of the posterior lake; in Dr. Leidy's, it can be traced to a connection with the anterior lake, which is probably the normal relation. Lakes not much expanded transversely to the crown.

The crowns of both specimens are prismatic. That of mine is nearly straight; Dr. Leidy's is slightly curved, but not so much so as in the *H. peninsulatum*.

		MM.
Diameters of crown	{ transverse.....	21.5
	{ anteroposterior.....	21.5
	{ longitudinal.....	450.0

From Tehuichila, State of Vera Cruz, Mexico, on the borders of Hidalgo; from a bed of Loup Fork age.

HIPPOTherium PENINSULATUM Cope.

Proceedings American Philosophical Society, 1885, p. 150, Fig. 1.

Crown of superior molar long, curved. Grinding face with anteroposterior diameter considerably exceeding the transverse. Internal column large, its section a narrow anteroposterior oval, with both borders convex. Internal enamel borders of internal crescents with a prominent loop at junction, the posterior one with its posterior loop much smaller than the column. A subquadrate area between the internal parts of the lakes is connected by an enamel ridge with the anterior lake. Opposite and adjacent enamel borders of the lakes, with several close and deep plications, which nearly cut off the adjacent horns. In like manner the posterior horn of the posterior lake, and the anterior horn of the anterior lake are almost cut off by the deep complex infolding of the anterior and posterior borders respectively. The median and anterior external ribs of the crown are well developed, and there is but little cement on the grooves.

<i>Measurements.</i>	M.
Length of root, less crown . . . . .	.050
Diameters of grinding face { anteroposterior . . . . .	.018
transverse . . . . .	.015

This superior molar tooth indicates a small species of the genus, and one which is entirely typical in form. The plication of the enamel is greater than any other species excepting the *H. gracile*. It resembles the *H. venustum* of Leidy, which is of similar dimensions. In that species the style has a nearly circular section according to Leidy, which distinguishes it satisfactorily. It approximates the *H. montezumæ* in the character of its plications, but the oblong form, small size and greater curvature distinguish it.

From the Loup Fork shales of Tehuichila, Vera Cruz.

HIPPOTherium SPECIOSUM Leidy.

Cope, Bulletin U. S. Geolog. Survey Terrs., No. 1, p. 12, Jan., 1874. Report Expl. Surv. W. of 100th Meridian, Vol. iii, p. 322, Pl. lxxv, Fig. 3, 1877.

Hipparion speciosum Leidy. Proceed. Phila. Academy, 1858, p. 27; Extinct Mamm., Dakota and Nebraska, p. 282, Pl. xviii, Figs. 6-19, 1869.

Hippodon speciosus Leidy. Proceed. Phila. Academy, 1854, p. 90.

This species appears to have been pretty generally distributed over Western North America, excepting the extreme Northwest. Among the numerous specimens sent me from Montana and Oregon, I have not recognized any as belonging to this animal. The species has been heretofore known by teeth only, in spite of its relative abundance; but my party in Northern Kansas, under Mr. Hill, obtained an almost perfect cranium accompanied by three cervical, four dorsal and one lumbar vertebræ, and part of the sacrum; with parts of foreleg and foot and one-half the pelvis. A superior molar of a second individual, from the same locality, is accompanied by a mandible with teeth, and bones of various parts of the skeleton. An opportunity for determining the general characters of this horse is now first presented.

Skull—form.—The cranium is about the size of that of the black-tailed deer (*Cariacus macrotis*). The profile of the front is nearly straight, with a slight convexity in front of the infraorbital region. The latter is flat or a little concave in both directions as far on each side as a line drawn anteriorly from the temporal fossæ; from these lines it slopes to the orbital border, flat posteriorly, becoming convex anteriorly, strongly so above the lachrymal bones. The profile of the parietal region descends steeply to a point above the meatus auditorius externus, and rising again into a prominent sagittal crest, joins the inion at the extremity of another descending slope. The inion is somewhat truncated at the summit. The anterior part of the sagittal crest is low, and divides at a very acute angle above the middle of the glenoid cavity. The horizontal angle of the malar and maxillary bones is prominent, extending forwards nearly to the anterior part of the first true molar. The preorbital fossa is limited in extent, occupying a position above the infraorbital foramen. Its sides rise gradually except on the upper border, which is abrupt. The muzzle is not excavated anterior to the fossa, but the usual contraction of the border of the diastema is strong. The acumination of the apices of the nasal bones is on their inner sides, and extends as far forwards as the line of the canine teeth. The notch of the nostrils extends to a point above the anterior border of the second (first large) premolar.

The zygomata are slender and little expanded, they are compressed behind. The orbital portion is triangular in section behind, with an external and a superior plane. The orbit is large and a little deeper than wide, the width equaling just one-fourth the distance from its posterior border to the extremity of the nasal bone. The postfrontal process presents its edge outwards and its broadsides directly fore and aft. The occipital region is rather contracted above. Its superior half is occupied by a median keel. The paroccipital process is long, extending considerably below the occipital condyles, and is compressed, presenting its sides outwards and inwards. A narrow strip of the os petrosum is exposed between the occipital and squamosal bones, extending as high up as the postnial fora-

men. The posttympanic process is distinct but short, presenting an obtuse edge outwards, which is separated from the petrous by a groove. The tympanic forms with the superficial layer of the petrous, a tube which encloses the tympanum, and which separates widely the posttympanic and postglenoid processes. The postglenoid is confined to the inner half of the posterior border of the glenoid cavity, and rises obliquely inwards to its apex. The inner border is vertical.

The palate is moderately flat, and is excavated behind as far as opposite the middle of the penultimate molar. The diastema in front of the canine is just half as long as that posterior to it. The width of the palate at the antepenultimate premolar is just twice the width of that tooth. The protuberance of the maxillary bone behind the last molar is about as long as the fore and aft diameter of the last molar. The pterygoid process of the palatine is not very long, and is slightly everted. Its superior border is thickened and somewhat roughened, and descends posteriorly without hamular process. The pterygoid wing of the sphenoid forms a prominent ridge directed downwards and forwards, which encloses the large alisphenoid canal. The pterygoid bone is a delicate scale at the inner side of the pterygoid ala, which extends as far back as the posterior alisphenoid foramen. The basioccipital and basisphenoid are convex in cross-section. The anterior part of the former is compressed, and the posterior part of the latter presents two low truncate tuberosities, outwards, backwards and downwards. The presphenoid region is contracted in the form of a part cylinder, which is underroofed by the laminar posterior part of the vomer, which extends nearly as far posteriorly at the sides as the posterior alisphenoid foramen.

Sutures.—The sutures are distinct in this skull. That separating the premaxillary and nasal bones is considerable, being about half as long as the nasomaxillary suture posterior to it. The nasolachrymal suture is about as long as the nasopremaxillary, and differs from it in being straight instead of convex upwards. The nasal bones are widened behind so as to be decurved laterally to the lachrymal. The posterior nasal sutures are each convex backwards. The lambdoidal suture crosses the sagittal crest in front of the inion and reaches the squamosal at the postparietal foramen. The postfrontal is only in contact with the zygomatic process of the squamosal, and at considerable distance posterior to the malar above, but opposite the posterior inferior slip of the malar. The latter bone extends as far forwards as the middle of the penultimate molar, and rises upwards nearly to the middle of the orbit. The lachrymal bone is a very large one; it is a little higher than the facial part of the malar, and extends a little further anteriorly. Its frontal suture is shorter than its nasal, and extends nearly to the middle of the superior border of the orbit. The premaxillo-maxillary suture passes into the incisive foramen at the canine tooth. The maxillopalatine extends forwards as far as the front of the first true molar, and posteriorly near to the last molar to the shallow groove between the maxillary bone and the pterygoid process.

Foramina.—The infraorbital is of good size, and issues above the posterior part of the fourth premolar. The lachrymal is rather large, and occupies a space but little below the middle of the lachrymal. The posterior infraorbital is large. The supraorbital is double and pierces the base of the postfrontal process. There are two postparietals of rather large size, and at least one large postsquamosal. A well-developed though narrow tentorial ridge defines the position of the lateral venous sinus in front. The mastoid foramen is, as in modern horses, not enclosed posteriorly on its external side, but winds round upwards and forwards, grooving the part of the petrous bone which rises within the mastoid. The *meatus auditorius* is small and the supraglenoid is large, but not so large as the postglenoid. There is but one, a large condylar foramen. The jugular, carotid and oval foramina are not distinguished from the *foramen lacerum*. The *f. f. opticum* and *sphenoorbitale* are distinct and close together; the *f. rotundum* is further back, entering the skull within the alisphenoid canal. The orbitonareal perforation is quite large, and is posterior to the posterior infraorbital canal, not having a common entrance with it as in the species of *Equus*. There is but one palatine foramen on each side, whose posterior borders are nearly in line with the anterior border of the nareal excavation. The incisive foramina do not extend posterior to the position of the nareal excavation. There is a small foramen on the median line just in front of them.

Dentition.—The condition of the teeth shows that the individual described had just reached maturity, since the last molar is not worn on the posterior part of its face. The cups of the incisors are fully enclosed, but the posterior part of the border of the third is not produced quite as far as that of the other teeth, and does not display such results of wear. The cup of the first is filled with cement; of the second and third not fully, but with a median fissure remaining. The size of the incisors decreases from the first to the third, not increases, as, *e. g.*, in *Equus quagga*. The canines are small, and have the equine sharp borders bounded by two grooves of the inner side.

The fourth premolar is two-rooted, but is small and is more than half overlapped by the third. The latter is not remarkably large nor particularly elongate. It is, however, relatively longer than in *H. calamarium*, where it is very wide. The molars diminish posteriorly by very little, the last being distinctly smaller. The internal free column of the molars has a longitudinally oval section, and its middle is a little anterior to the middle of the crown. It has a small apiculate angle directed forwards and outwards. On the large third premolar it has a round section, and joins the internal anterior crescent by a very narrow isthmus. The posterior column is connected with the posterior inner crescent by a narrow isthmus in all the molars, and has in all the flattened form of the anterior column. The lakes as usual are enclosed, and the crescents communicating; this is true of the third premolar as of the others, except that the anterior lake opens forwards and inwards. The adjacent borders of

the lakes are complicated, and so is the posterior border of the posterior lake; the anterior border of the anterior lake is simple. There are two or three loops on the posterior border of the anterior lake, the inner one of which is deep, and nearly or quite reaches the ends of one or two deep loops which enter from the inner border. These nearly or quite cut off a large lobe into a small subround lakelet. This is present on all the teeth and is seen in Dr. Leidy's figure of his typical specimen, though not quite so strongly marked. It is also present but less marked in the New Mexican specimen I have described.* There are four or five inflections of the anterior border of the second lake, and two or three of the inner border at its posterior part. The external ridges of the crowns are well developed, and the cement layer on the external and internal faces of the crowns, as well as in the lakes, is uninterrupted. The crowns do not display any part of the roots, and their wear is in two shallow grooves, a median and a posterior.

Measurements of Cranium.

	M.
Length below (including condyles).....	.315
" from edge of incisor i to extremity of maxillary bone.....	.220
Length from edge of incisor i to extremity of palate.....	.170
" " " " fourth premolar (axial)....	.078
" " " " canine (axial).....	.044
" of zygomatic fossa.....	.055
" from incisor i to edge of orbit.....	.190
" " nostril " " " .....	.115
" " anterior edge of orbit to top of inion.....	.150
Horizontal diameter of orbit .....	.048
Width between orbits above (direct).....	.087
Greatest width of zygomata.....	.130
Width of muzzle above preorbital fossæ.....	.040
" " " " nareal angle.....	.032
" between third incisors.....	.037
" " diastemata posteriorly.....	.027
" " third premolars.....	.034
" " last true molars.....	.050
" " pterygoid crests at postalisphenoid foramen..	.021
" " apices of postglenoid processes.....	.070
" of occipital condyles .....	.050
" " foramen magnum.....	.022
" " occiput at summit.....	.030
" " " " mastoid foramina.....	.062
Length of molar series.....	.125
" " third premolar.....	.025
Width " " " (greatest).....	.014

* Report U. S. G. G. Survey W. 100th Mer., Vol. iv, p. 322, Pl. lxxv, Fig. 3.

on both the anterior and posterior borders for adjacent diapophyses. The posterior are larger, and are transverse oval. The postzygapophyses are prominent, but narrow; the prezygapophyses have a vertical external face and concave internal face; the superior border is not rolled in as in *Booidea*. No hypapophysis. The anterior two elements of the sacrum are preserved, the rest having been lost. They are thoroughly co-ossified, and the intervertebral foramina are large. The prezygapophyses are like those of the last lumbar. The iliac surface only extends on two centra.

A comparison of the dorsal vertebræ with those of the horse shows that those of this species are more tapiroid in the general isolation of the spinous foramina in the anterior part of the column.

Measurements.

	M.
Elevation of axis at middle .....	.055
" of spine of do., from roof of arch behind.....	.015
" of neural canal of do., behind.....	.014
Length of spine on side.....	.049
Width of cup of axis.....	.021
Length of centrum last cervical.....	.045
Diameter ball of do., { vertical.....	.018
{ horizontal.....	.014
Expanse of postzygapophyses do.....	.041
Elevation of neural spine from canal.....	.024
Diameters centrum anterior dorsal { fore and aft. ....	.024
{ anterior { vertical.....	.016
{ { transverse...	.024
Length of neural spine from canal in front .....	.065
Length centrum of a posterior dorsal.....	.028
Width anteriorly without costal faces .....	.018
Depth " " " " .....	.017
Length of neural spine from canal anteriorly.....	.107
Diameters last lumbar { long.....	.030
{ anteriorly { vertical .....	.015
{ { transverse.....	.023
Anteroposterior width of diapophysis of do. ....	.035
Total expanse of sacrum in front.....	.098
Depth of centrum of do., anteriorly .....	.013
Width of neural canal in front.....	.020

Anterior limb.—About the distal half of the humerus is preserved. Its form is much like that of the horse, the inner side being flat, and the outer concave at the position occupied by the epicondyle when present. The external supracondylar ridge is distinct but not prominent. The trochlear crest has the same position as in the horse, and is rather more prominent. The condylar surface exterior to it is not cut off above and

behind by a groove, as in the horse. The superior grooved boundary of the internal condylar face is better defined. The ulnar and radial shafts are coössified, but the head of the radius is not united with the ulna, though in contact. Distad to this contact, is a considerable interosseous space, relatively longer than in the horse. The line of contact of the head of the radius is convex downwards in the middle. Olecranon much compressed. The carpal articulation of the radius is like that of the horse. The scapho-lunar ridge is transverse; the scaphoid surface recurved below, and a fossa behind the lunar surface. The convex superior surface of the bone has five facets, two of which are more or less lateral.

The left metacarpus and *os magnum* are preserved; the magnum has a relatively smaller transverse diameter than in the horse; its posterior tuberosity is also narrower. The facets of the inter side are much less pronounced than in the horse, the whole being divided by an anteroposterior groove. On the internal side the two anterior or trapezoid facets are as large as in the horse, while the posterior facet of the recent animal is absent from the *H. speciosum*. The magnum facet of the metacarpal is uninterrupted, not divided, as in the horse. The two unciform facets are much more oblique than in the horse. The trapezoides differs considerably from that of the horse. It has but one facet below, and that one is continuous with that of the metacarpal. It sends posteriorly a hook-like process. Above, it encloses no foramen with the magnum. The bevels for the lateral metacarpals are distinct throughout the bone. The posterior face is divided distally by a median obtuse ridge into two shallow gutters, a character not seen in the horse. There is no trace of the trochlear keel on the anterior face of the distal extremity. The section of the shaft at the middle is at least a semicircle. The phalanges of the middle toe have the form usual among these animals. They are rather more slender than in some of the allied species, as *H. isonesum*, and the proximal inferior triangular surface is more produced, reaching to the end of the proximal two-fifths of the length. It forms a large triangular face, concave in the middle.

Measurements of Fore Limb.

M.

Diameters of humeral condyles	{ anteroposterior at inner side . . . . .	.045
	{ " at middle . . . . .	.021
	{ transverse . . . . .	.040
Depth of ulna at edge of head of radius . . . . .		.019
Distal width of radius . . . . .		.038
" depth of radius (greatest) . . . . .		.024
Diameters of scaphoid facet	{ anteroposterior . . . . .	.016
	{ transverse . . . . .	.016
Diameters of lunar facet	{ anteroposterior . . . . .	.014
	{ transverse . . . . .	.016
Diameters of os magnum	{ anteroposterior . . . . .	.023
	{ transverse . . . . .	.022
	{ longitudinal . . . . .	.011

M.

Anteroposterior width trapezoides	{ external.....	.015
	{ internal.....	.011
Length of median metacarpal.....		.164
Proximal diameter	{ transverse (total).....	.025
	{ anteroposterior.....	.017
Diameters of middle of shaft cannon bone	{ anteroposterior..	.015
	{ transverse.....	.017
Length proximal phalange.....		.044
Proximal width of do.....		.026
Length of second phalange.....		.025
Proximal width do.....		.024
Length proximal lateral phalange (measured at middle)...		.023
“ ungual “ “ “ “		.018

The *os innominatum* differs in a number of respects from that of the horse, although its general characters are equine. The peduncle of the ilium is long and slender and subtriangular in section, and the ischium has a long anteroposterior diameter. The postacetabular crest is prominent, but not very acute. The pubis is subcylindric in section, and is not concave above as in the horse. The posterior bifurcation of the ischia is not so extensive as in the horse. Pectineal ridge more prominent than in the horse.

M.

Length of ilium from fossa lig. teris to edge of crest.....	.180
Diameter of peduncle externally at middle.....	.024
“ “ acetabulum (long).....	.033
Length of ischiopubic median suture.....	.065
“ “ obturator foramen.....	.040
“ “ ischium remaining posterior to obturator foramen.....	.042

HIPPOTHERIUM PLICATILE Leidy.

This species is represented by two superior molar teeth and probably by numerous bones, in the collection of Prof. Jos. Leidy. They are all from the Loup Fork bed of Florida. The crowns of the molar teeth are elongate and nearly straight. The anterior internal column is median in

position, and is much more prominent than the posterior. Its section is subregular oval. The posterior column is a large process of the posterior inner crescent. The lakes are expanded transversely and their remote borders have the usual deep notch. The adjacent borders are very complex with rather shallow inflections, with the usual large loop of the anterior lake represented by two narrow excurrent folds with irregular borders. The crowns wider than long.

MM.

Diameters of grinding face (Leidy)	anteroposterior.....	20
	transverse.....	23

This species possesses teeth of the *H. speciosum* type, but with such a distinct style of enamel plication as to preclude the idea of identity with that species.

From near Archer, Florida, Dr. Neal.

HIPPOTHERIUM GRATUM Leidy.

Extinct Mammalia of Dakota and Nebraska, p. 287, Plate xviii, Figs. 25, 30. *Hippotherium ingenuum* Leidy, Proceeds. Acad. Phila., 1885, p. 33, Fig.

This species is represented in my collection by two superior molars with lower jaws of three individuals, and two posterior superior molars of another individual from the Loup Fork bed of Northern Kansas. Dr. Leidy examined five superior molars from the corresponding horizon of Northern Nebraska.

These specimens indicate a small species of general affinity to the *H. speciosum*. The internal column is prominent at or before the middle of the crown in position, and of regular oval section. The posterior internal column is small and not prominent, and is well defined externally by a deep sinus. The opposed borders of the lakes are folded into several narrow sinuses, and the loop of the anterior lake is large and subround. The plication is of intermediate character. The posterior face of the crown of the last superior molar is deeply grooved longitudinally. In a pair of these molars which are well worn, the adjacent borders of the lakes have reduced their plications to serrations, and the loop to a prominent convexity. The posterior lobe is still well defined, and the anterior internal column touches the anterior internal crescent. The difference between these and typical teeth is as great as that distinguishing species, but I believe it is due solely to wear. A similar simplification is seen in the *H. paniense* and *H. speciosum*.

MM.

Diameters of a superior molar	anteroposterior	19
	transverse	18
Diameters of a last sup. molar, little worn	anteroposterior..	19
	transverse.....	14
Diameters of a last sup. molar, much worn	anteroposterior..	18
	transverse.....	16

The mandibular rami which probably belong to this species present the character of an uninterrupted series of canine and incisor teeth. The symphysis is contracted, and the rami increase rapidly in depth. The diastema is long. No trace of fourth premolar.

Measurements.

	MM.
Length of symphysis.....	37
“ “ diastema	46
Depth of ramus at posterior border of p. m. iv.....	40

HIPPOTHERIUM RETRUSUM Cope.

This species is represented in my collection by eight molars, two from one and six from another animal. These are associated with two superior molars with somewhat different characters, which are intermediate between those of *H. gratum* and *H. speciosum*. All were found in the same locality, but separated from their positions in the skull. The two molars first above mentioned are about half worn, and present the characters of the species best. The other six (with one exception) are less worn, and present a less complex folding of the enamel plates. Five of them are from one side, and one (more worn) from the other side of the jaws.

The character by which the superior molars of the *Hippotherium retrusum* may be readily distinguished from those of all other species of the genus, is the extraordinary posterior extension of the anterior internal column, which brings it first into contact with the posterior internal column, and then on greater wear unites the two by an isthmus. In the first true molar the area of the column is in contact at its extremities with both the posterior column and the anterior inner crescent, leaving a narrow oval area (or lake) within it, cut off at both extremities. In the second molar the column is only in contact with the posterior internal crescent, with which it is united by an isthmus. In both the molars the posterior inner column is well distinguished by the usual deep sinus from the posterior inner crescent. The character above described is an exaggeration of what is distantly approached by the last superior molar in some of the species.

The complexity of the enamel border of the lake is of medium degree. The anterior lake has on its posterior border a large more or less completely isolated wide loop. Exterior to it the adjacent borders of both lakes are thrown into narrow anteroposterior folds. No fold on remote border of anterior lake, and a weak one at the corresponding position on the posterior lake. A short small loop towards the internal column on m. ii. The crowns are robust, of medium length, and curved. That of the second true molar is rather longer than wide; the first true molar is about as wide as long.

Measurements of Superior Molars.

	MM.
Diameters m. i { anteroposterior.....	19
transverse.....	18.5
longitudinal.....	26
Diameters m. ii { anteroposterior.....	20
transverse.....	18
longitudinal.....	36

The anterior inner column presents in the second individual the same flattened form as in the first above described, but it is connected with the anterior crescent by a narrow isthmus, and not in two of three teeth at least, where the part is preserved, with the posterior crescent. The anterior molar (third premolar from behind) has this junction a complete fusion of the two. As one of these teeth is a true molar it is possible that they represent another species.

The animal last described may possibly belong to a species distinct from the *H. retrusum*, and perhaps to a species of *Protohippus* or *Hippidium*. If so, it differs from the known species of those genera in the posterior position and flatness of the anterior column. In that case it may be called *P.* or *H. profectus*. It approaches nearer to *Equus* than any known species of those genera.

Measurements of No. 2.

	MM.
Diameters of p. m. i { anteroposterior.....	45
transverse.....	23
longitudinal.....	19
Diameters of m. iii { anteroposterior.....	24
transverse.....	20
longitudinal.....	36

In dimensions this species is then about equal to the *H. speciosum*.

From Phillips county, Kansas, from the Loup Fork bed. Frank Hazard.

HIPPOTHERIUM PANIENSE Cope.

Bulletin U. S. Geolog. Survey Terrs. (Hayden), No. 1, 1874, p. 12. Annual Report U. S. Geolog. Survey Terrs., 1873 (1874), p. 522.

This species is known from molar teeth from the Loup Fork beds of N. E. Colorado. The enamel borders differ in their degree of complexity according to the amount of wear to which they have been subjected.

In the molar which presents the more simple type of enamel borders, the posterior internal column is entirely fused with the posterior inner crescent. The anterior inner column is therefore alone. It is nearly round in section, and presents no angular apex towards the inner crescents, and there is only a trace of the loop which is usually directed towards it from the enamel border connecting the crescents. The borders

of the lakes only show indication of plication on their adjacent faces ; here the anterior has traces of three loops and the posterior of one. Cementum full within and without.

A second superior molar is not so much worn, and displays more plication of the enamel plates. The crown is curved and not elongate. The posterior inner column is not lost, and the anterior column is not so round in section, but is a short oval. It presents no angle towards the enamel borders of the inner crescents, but there projects a single small loop opposite the middle of the column. The folds of the lakes are confined to their adjacent faces, thus agreeing with the tooth No. 1. The folds are also very few, but much deeper than in No. 1. On the posterior lake there are three, the inner one deep ; on the anterior lake, one deep one, and another rather deep entering from the inner side approaches it. Slight undulations of the posterior border of the posterior crescent take the place of the folds of other species.

The *Hippotherium paniense* evidently differs from the other species in the coincident cylindric form of its internal column, with the greater simplicity of its enamel plates.

Measurements.

No. 1.		M.
Length of crown on middle of side.....		.012
Diameters grinding face {	anteroposterior.....	.020
	transverse.....	.021
“ inner column .....		.005
No. 2.		
Length of crown on middle of side .....		.016
Diameters grinding face {	anteroposterior.....	.019
	transverse.....	.020
“ of inner column.....		.005

I obtained the teeth of this species in 1873 from the Loup Fork beds of the Pawnee Buttes in Northeastern Colorado.

HIPPOTHERIUM VENUSTUM Leidy.

Proceedings Academy Phila., 1853, vi, p. 241 ; Holmes, Post Pliocene Fossils of South Carolina, 1859, p. 105, Plate xvi, Figs. 32-3.

For the character of this species I am compelled to rely on Leidy's figures above cited, as the description at the latter reference cited (there is none at the first) gives no assistance.

According to the figures in question, the anterior internal column is median in position, and is nearly round in section. The posterior internal column is small and loop-shaped in section. A single narrow loop of the middle enamel border is directed towards the anterior internal column. The lakes both have the usual inflection of the border on their remote

sides. The adjacent borders are much inflected with simple deep folds, and there is not represented to be any material difference between the larger loops towards the inner sides of the lakes.

The species is one of the smallest of the genus, being about equal to the *H. peninsulatum*. The crowns are represented to be elongate and but little curved. Grinding face longer than wide, 19 by 17 mm.

Deposits of Ashley river, near Charleston, South Carolina. The fossils of this deposit are of mixed ages, so that it is impossible to fix its true horizon with certainty.

HIPPOTherium RELICTUM Cope.

American Naturalist, March, 1889.

Crowns of superior molars as broad as, or broader, than long, rather short and moderately curved. Anterior internal column with a broadly oval section, without angle, and well separated from adjacent enamel borders. Posterior internal column on the first true molar, projecting as far inwards as the anterior, but broadly connected with the posterior internal crescent. It is not so far inward in the last superior molar, with which it is connected by a rather narrow isthmus. The enamel border of the lakes is very simple, consisting in the first true molar of one or two emarginations of the adjacent faces, and one or more of the remote margins. A loop of the posterior internal border of the lakes is outlined. A small loop directed towards the anterior internal column. Cementum layer thick.

Dimensions of Molars.

		MM.
Diameters m. i	{ anteroposterior.....	16
	{ transverse.....	19
Diameters m. iii	{ anteroposterior.....	17
	{ transverse.....	18.5
Diameters m. i, inferior	{ anteroposterior.....	17
	{ transverse.....	8
Diameters m. iii, inferior	{ anteroposterior.....	18.5
	{ transverse.....	8

From a Lower Pliocene bed (? Idaho terrane) of the eastern part of Oregon. George C. Duncan.

HIPPOTherium SPHENODUS Cope.

Hippotherium speciosum Leidy, Cope, Bulletin U. S. Geol. Survey Terrs., No. 1, 1874. Annual Report U. S. Geol. Survey Terrs., 1873 (1874), p. 522; not of Leidy.

Two superior molars of this species were obtained by me in the same locality as that furnishing the *H. paniense*, and at the same time. Several years later I obtained two other molars from the same place, viz., the Pawnee Buttes of N. E. Colorado.

Their characters are somewhat similar to those of *H. speciosum* in the plications of the enamel, but the form of the internal columns is entirely distinct, referring the species to the group of the *H. calamarium*. The latter species is, however, distinguished by the very short wide form of the anterior teeth, especially of the second premolar. While noting this character in the Report of Lieut. Wheeler, as above cited, I did not regard it as specific. Having obtained another similar specimen, I am now inclined to attach more importance to it. It indicates that the *H. calamarium* exhibited a greater facial concavity at the diastema than any other species known from this country.

In this species the anterior distinct column has an oval section with an angle directed to the anterior inner crescent. The enamel border connecting the crescents sends towards the column two loops. The borders of the lakes are plicate on their inner and adjacent sides. The front of the anterior lake has a deep notch, and three still deeper ones enter from the posterior inner border. There are two others on the posterior outline. The adjacent face of the posterior lake has four inflections, and there are two deep ones on the posterior part of the inner border. The posterior crescent sends an angle backwards, which is separated from the posterior inner column by a deep notch. The third premolar is narrowed and somewhat produced forwards, and its anterior inner column though distinct is reached by the narrow loop of the inner enamel border. The anterior inner crescent is peculiar in being distinct and isolated, so that the cementum of the anterior lake communicates with that covering the anterior inner side of the tooth. In the second and less worn specimen, the two lakes also have a narrow communication. The former character is found in *H. calamarium* and *H. isonesum*, but not in *H. speciosum*.

Measurements.

No. 1.		M.
Diameters crown third premolar	{ longitudinal .....	.018
	{ anteroposterior .....	.025
	{ transverse at column....	.019
Diameters crown left molar	{ longitudinal .....	.015
	{ anteroposterior .....	.022
	{ transverse .....	.021
No. 2.		
Diameters crown second premolar	{ longitudinal .....	.028
	{ anteroposterior .....	.025
	{ transverse at column..	.014
Diameters crown right superior molar	{ longitudinal .....	.019
	{ anteroposterior .....	.022
	{ transverse at column	.022

The specimen No. 1 equals that of *H. speciosum* in dimensions; No. 2 is a little larger.

HIPPOTherium CALAMARIUM Cope.

Annual Report of U. S. Chief of Engineers, 1875, ii, p. 990. Report U. S. G. G. Survey W. of 100th Mer., G. M. Wheeler, p. 321, Pl. lxxv, Figs. 1-2.

With this species we enter the group characterized by the general equality in size and form of the anterior and posterior internal columns of the superior molars, and the presence of a rudiment in the anterior column, of an isthmus corresponding with that one which connects the posterior inner column with the posterior inner crescent.

The *H. calamarium* has been found especially abundant in the Loup Fork bed of Pojuaque near Santa Fé, New Mexico, and I have a portion of a maxillary bone supporting two molars, from the corresponding horizon of Northeast Colorado, which may be placed here provisionally in the absence of the third superior premolar. The borders of the lakes are of medium complexity only, and the posterior loop of the anterior lake is rounded, and is not much constricted. The anterior inner crescent of the third (anterior) premolar is isolated. This tooth differs from the corresponding one of the *H. sphenodus* and the *H. isonesum* in its short, wide form. Should the latter character be found not constant, I do not know of any way of distinguishing it from the latter. In the former the posterior internal column is less prominent and smaller, much as in *H. speciosum*, etc. Cementum layer thick. Crowns nearly square, short, curved.

Measurements of Specimen from Colorado.

MM.

Diameters of m. i	{	anteroposterior	24
		transverse.....	24

HIPPOTherium ISONESUM Cope.

Hippotherium seversum Cope, Proceeds. Amer. Philos. Society, 1886, 359, not of 1878, p. 76.

Judging from the relative abundance of specimens, this was the common species of the far Northwest of the United States during the Upper Miocene period. I have the large part of a skeleton with skull from Cottonwood creek, Oregon; parts of maxillary bones with teeth of a second individual from the same locality, with some teeth of a third from the same. There are a good many teeth of the same species from the Ticholeptus bed of the valley of Deep river, Montana, a number of which belong to one individual.

In the subequal characters of the two inner columns of the superior molars, the species betrays an approach to *Protohippus*, which is emphasized by the angular projection of the anterior column towards the anterior internal crescent. The two however never join, and only come into contact in one instance, in the third premolar of a Montana specimen.

As the skull belongs to an animal not quite adult, I describe the dental characters from the second individual mentioned as having been sent from the same locality in Oregon. In this one it is observable that the inner edges of the cups of the incisors are well developed, but the latter are only partly filled with cementum. The fourth premolar is two-rooted and is half overlapped by the third. The latter is of usual form, produced anteriorly. The anterior inner crescent is distinct from the posterior inner, but is narrowly connected with the anterior outer. The lakes have a narrow communication. In the molars of typical form the posterior internal column is almost cut off from the adjacent crescent by the deep posterior notch or loop, which also narrows the posterior crescent at this point. The borders of the lakes are not much complicated in this specimen. They display on the third premolar only one well marked inflection on their adjacent faces, and two (one minute) on the posterior part of the internal border in both. The posterior extremity of the posterior internal crescent sends an angle inwards along the edge of the crown. One or two loops point towards the internal column.

In the Montana series, the premolars and first true molar of one side are preserved, and two true molars of the opposite side. Their crowns are less worn than those just described, and the enamel borders of the lakes display more numerous inflections. Thus the anterior border of the posterior lake has three deep inflections, while the adjacent boundary of the anterior lake has but one; this one however bounds a loop by nearly joining another deep notch entering from the inner posterior direction. Then there is a deep notch in each lake coming from the direction of the anterior and posterior margins of the crown respectively. One loop extends towards the inner column.

In the Oregon skull, already mentioned, the superior molars display different degrees of wear in such a way as to be very instructive. The premolars are least worn; and in them we observe (1) that the posterior internal column is distinct from the adjacent crescent like the anterior one; (2) that the mutual connections between the internal crescents are very narrow; and (3) that the inflections of the borders of the lakes are few and shallow. In the second true molar, which is a little more worn, there is one deep inflection on the adjacent border of each lake, of which the anterior one nearly cuts off a loop by approaching a notch from the inner side. In the first true molar, which is, of course, the most worn, the posterior lake has the full number of three notches on its anterior border.

The masticating surface of the molars of this species is worn into transverse angular grooves and ridges more distinctly than in any other species of the genus.

The *cranium*, already mentioned, is somewhat distorted by pressure, but many characters are clear. The facial concavity is different from that of *H. speciosum* in its greater size and more posterior extension, and also in its expansion downwards to the maxillo-malar ridge, as in certain

species of *Protohippus*. The postorbital process turns its edge outwards. The external extremity of the glenoid cavity is quite prominent. The posttympanic process is short and acute. The palatine foramina are opposite the posterior edge of the first true molar. The supraorbital foramen is large and distinct. The infraorbital foramen issues above the middle of the fourth premolar. The palate is as narrow as in *H. calamarium*, but the premolar teeth are narrower; the greatest transverse diameter of the second premolar in *H. isonesum* is two-thirds that of the palate between them while it is equal in *H. calamarium*.

Measurements of Skull.

	M.
Length from incisors to occipital condyles.....	.328
“ “ to glenoid surface (axial).....	.257
“ “ to end of os maxillare.....	.210
“ “ to p.m. iv (axial) ...	.068
“ “ to canine “ .....	.037
Transverse diameter of orbit.....	.044
Width at paroccipital processes.....	.034
“ between first true molars .....	.044
“ “ second premolars.....	.030
“ at diastema near p.m. iv.....	.028
Long diameter p. m. iv .....	.013
Diameters p.m. iii { anteroposterior.....	.024
{ transverse (at column).....	.014
Diameters m. i. . { anteroposterior .....	.019
{ transverse.....	.019
Long diameter of crown of I. i.....	.013

The only *vertebra* of this individual, which is well preserved, is an atlas. This one has the general proportions of that of the horse, but differs materially in the less anterior extent of the transverse process. This does not, as in the horse, enclose the anterior arterial foramen, which is therefore represented by a notch. The hypapophysis is well marked, and the condyloid cavity deeply notched on the external side. The first dorsal is strongly opisthocoelous, its ball is subquadrate. There is a strong obtuse hypapophysial ridge. The anterior capitular articulation is large and flat.

The last two lumbar are preserved somewhat injured. They are united mutually and with the first sacral by rather large articular surfaces of the diapophyses. The penultimate has an obtuse hypapophysial keel, which is less distinct in the last one.

Measurements.

	M.
Length of atlas on side.....	.052
Expanse of atlas transversely .....	.086
Width of canal behind.....	.023

Measurements.

	M.
Diameter of ball of d. i. { vertical .....	.018
{ transverse.....	.018
Diameters of ball of a posterior lumbar { vertical.....	.018
{ transverse .....	.027

The larger part of the *pelvis* is preserved. It agrees with that of *H. speciosum* and differs from that of the horse in the subcylindric pubes, but it differs from that of the former in having the peduncles of the ilium flatter or deeper fore and aft. The peduncles of the ischium are robust, and are concave on the outer and convex on the inner side, less convex, however, than in the horse. The obturator foramen is a more elongate oval.

Measurements.

	M.
Length of ilium .....	.150
" of pubis .....	.045
" of obturator foramen .....	.040
Width of ischia at end of foramen.....	.060
" of acetabulum vertically.....	.033

Both *femora* are preserved. They display the usual equine characters of long great trochanter and large third trochanter, which is half opposite the inferior half of the prominent keel-shaped small trochanter. The shaft is robust, rather compressed and slightly curved fore and aft. Its section at the middle is an anteroposterior oval. The internal crest of the rotular groove is higher than the external posteriorly, and projects as well a little inwards; it is not, however, developed to anything like the extent seen in the horse. The rotular groove is rather wide and is cut off from the external condyle only by a fossa. The intercondylar fossa is rather wide. The supracondylar fossa is large and of subcircular form; it marks one-third the distance between the condyle and the third trochanter.

Measurements of Femur.

	M.
Total length (axial) .....	.260
Elevation of great trochanter .....	.030
Length from apex of great trochanter to middle of third trochanter.....	.096
Width at head.....	.068
" " third trochanter (middle) .....	.052
" of shaft at middle.....	.022
" at condyles.....	.050
Transverse diameter of shaft at middle.....	.031

The *tibia* is not so robust in its proportions as that of the horse or quagga, but is about as in the *Anchitherium præstans*. It is smaller than

the tibia of the latter, although the sizes of the crowns of the teeth in the two species is about the same. The crest is narrower and more prominent than that of the horse and quagga, and similar to that of the *A. præstans*. It differs from that of the latter in the entire coössification of the distal extremity of the fibula and entire absence of the splint-like shaft seen in the adult *A. præstans*. The spine is well marked and widely divided, and the external anterior notch is deep. The popliteal fossa is well marked. The shaft is flattened from side to side, and presents an obtuse edge outwards along the middle of its length. It is not marked by muscular and other impressions as in *Anchitherium præstans*. The distal end is much like that of the species just named; both differ from those of the horse and quagga in having the internal tuberosity of a more oblong form and less prominent.

Measurements of Tibia.

	M.
Total length .....	.253
Diameters of head { anteroposterior .....	.047
{ transverse .....	.060
Diameters of middle of shaft { anteroposterior .....	.020
{ transverse .....	.028
Diameters of distal extremity { anteroposterior .....	.023
{ transverse .....	.041

The *tarsus* is represented by calcaneum, astragalus, navicular and ectocuneiform. The first two do not differ from the corresponding bones of an undetermined *Protohippus* beyond their somewhat smaller size, excepting in the better developed calcaneal facet on the external margin of the astragalus. The astragalus agrees with that of the undetermined *Protohippus*, and differs from that of the horse in three points: (1st) The less extension inward of the distal tuberosity and navicular facet; (2d) the greater compression of the trochlear keels; (3d) the distinct extension of the prominent inferior margin of the internal superior trochlear smooth surface, to the internal distal tuberosity. The quagga is intermediate in these points. The facets of both surfaces of the navicular are not so much subdivided as in the horse, but more so, as to the upper surface at least, than in the *Anchitherium præstans*. Its anterior portion is not so expanded outwards as in the horse, but is considerably more so than in *A. præstans*, and about as in *Protohippus*. The same statements apply to the ectocuneiform. The superior facets are divided as in the horse, but inferiorly the posterior facet is a branch of the anterior, not distinct from it as in the living species.

Measurements of Tarsus.

	M.
Length of calcaneum .....	.070
" " sustentaculum .....	.049
Greatest width of calcaneum .....	.030
Depth of sustentaculum at middle .....	.028

<i>Measurements of Tarsus.</i>		M.
Greatest diameters of astragalus	{ anteroposterior .....	.038
	{ transverse .....	.035
Width between centres of trochlear crests.....		.015
Transverse extent of navicular facet.....		.021
“ “ “ cuboid.....		.006
Diameters of navicular	{ longitudinal .....	.008
	{ anteroposterior.....	.024
	{ transverse .....	.027
Diameters of ectocuneiform	{ longitudinal .....	.007
	{ anteroposterior .	.019
	{ transverse .....	.025

The *metatarsals* are smaller than those of the undetermined Protohippus and still smaller than those of *Anchitherium præstans*. The third is of generally similar form in all three of the species, though the proximal extremity has not quite so much anteroposterior width in *H. isonesum* as in the other species. In all of them it is more convex than in the horse. It also differs from that of the horse in not having the posterior facet cut off from the anterior. It is partially cut off by a deep sinus in this species and the undetermined Protohippus, which sinus is only represented by a notch in *A. præstans*. The lateral metatarsals are slender medially as in the undetermined Protohippus, and not so stout nor so much compressed in *Anchitherium præstans*. They do not quite reach to the articular surface of the median metatarsal, being a very little shorter than in the Protohippus and *Anchitherium* mentioned. The phalanges of the *H. isonesum* have about the same diameter as those of the undetermined Protohippus, but they are distinctly shorter, especially the pastern. The coffin bone differs from that of the same species in the smaller size of the proximal lateral fossæ.

<i>Measurements of Foot.</i>		M.
Length of m.t. iii.....		.175
Proximal diameters m.t. iii	{ anteroposterior .....	.019
	{ transverse.....	.025
Diameters shaft m.t. iii	{ anteroposterior.....	.015
	{ transverse.....	.018
Distal diameter m. t. iii	{ anteroposterior.....	.019
	{ transverse.....	.021
Length m. t. iv .....		.159
Anteroposterior diameter m. t. iv, proximally.....		.020
“ “ “ ii, “ .....		.014
“ “ “ ii, medially.....		.006
Length of pastern laterally.....		.033
Width of do. distally.....		.019
Length of coronary on side.....		.025
Width of do. distally.....		.019
Length of coffin bone in front.....		.031
Expanse of do. posteriorly.....		.030

This three-toed horse was of about the size of the *Hippotherium speciosum*, which I have already shown to have been equal to the prong-horned antelope, but of somewhat different proportions.

This species stands in a certain relation to the *Protohippus insignis* Leidy, a species which is common in the Eastern beds of Loup Fork age. Should the anterior internal column unite with the anterior internal crescent, thus developing the character of the genus *Protohippus*, it is doubtful whether the two species would be distinguishable by the dentition. I have not seen, however, any intermediate specimens, and the two species occupy different geographical areas. A somewhat similar relation exists between the *H. sphenodus* and the *P. perditus*, but in the former the enamel lake borders are much more complex.

HIPPOTHERIUM SEVERSUM Cope.

Stylonus severus Cope, Paleontolog. Bulletin, No. 30, p. 14. Proceed. Amer. Philos. Society, 1878, p. 76.

The *H. seversum* was originally described from a superior molar, which though worn over the entire grinding face of the crown still retains the posterior column distinct from the posterior inner crescent. On this account I distinguished the species generically from *Hippotherium* under the generic name *Stylonus*. I think, however, that a little further wear would reveal the union between the two parts of the crown above mentioned, which would then present characters not distinguishable from those of *Hippotherium*.

Crown of superior molar moderately elongate and curved. Grinding face subquadrate. External ridges prominent. Section of anterior internal column oval, with an apex directed outwards at a short distance anterior to the single internal median loop. Posterior internal column also oval in section, distinct from posterior internal crescent, and without apiculate angle in specimen at present state of wear. Crescents narrow, separated by rather wide lakes entirely filled with cementum. Lake borders simple; anterior with a trace only of anterior notch; posterior with a strong posterior notch. Opposed adjacent borders with one notch on the posterior and two on the anterior crescents, the latter enclosing a small loop in the usual position. External cement layer rather thin.

Measurements.

	MM.
Diameters crown { anteroposterior.....	18
{ transverse.....	17
{ longitudinal.....	28

Ticholeptus bed of Cottonwood creek, Oregon; Dr. J. L. Wortman.

This species differs from both the *H. isonesum* and *H. calamarium* in its inferior dimensions, and in the simplicity of its enamel lake borders.

EXPLANATION OF PLATES.

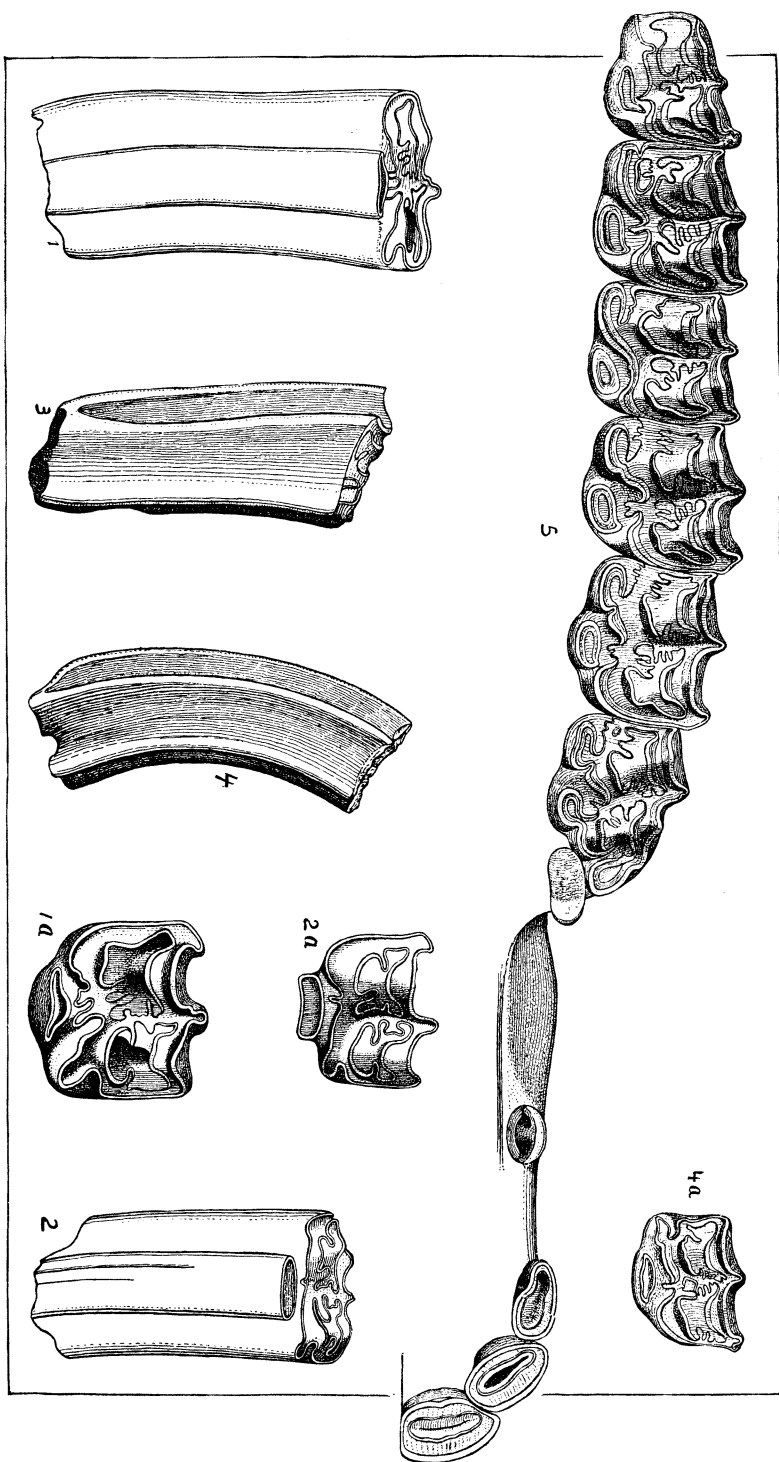
Figures of superior molar teeth of species of *Hippotherium*, natural size.

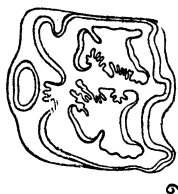
- Fig. 1. *Hippotherium occidentale* Leidy; superior molar, from Cottonwood creek, Oregon; internal view; *a*, grinding face.
Fig. 2. *H. sinclairii* Wortman; inner view; *a*, grinding face.
Fig. 3. *H. rectidens* Cope; side view; *a*, grinding face.
Fig. 4. *H. peninsulatum* Cope; side view; *a*, grinding face.
Fig. 5. *H. speciosum* Leidy; including canine and incisor teeth. From Kansas.
Fig. 6. *H. plicatile* Leidy; grinding face; from Leidy.
Figs. 7-8. *H. retrusum* Cope; first and second molars, grinding faces; *a*, posterior view of 7. From Kansas.
Figs. 9-12. Superior molars doubtfully referred to *H. retrusum* or to *Protohippus* or *Hippidium profectum*; grinding faces. From Kansas.
Figs. 13-14. *H. paniense* Cope, from Colorado; *a*, posterior view of 13.
Fig. 15. *H. calamarium* Cope, from New Mexico; from Cope in Report Expl. Surv. W. of 100th Mer.; G. M. Wheeler.
Figs. 16-17. *H. gratum* Leidy, from Kansas; *a*, anterior view of 16, which is an m. iii, little worn. 17. *a*, posterior do. of 17, much worn.
Fig. 18. *H. venustum* Leidy, from South Carolina; grinding face; *a*, interior view. From Leidy.
Figs. 19-20. *H. relictum* Cope, from Oregon; *a*, anterior view of 19.
Figs. 21-22. *H. sphenodus* Cope, from Colorado. 22. Anterior premolar.
Fig. 23. *H. isonesum* Cope, from Oregon; including canine and incisor teeth.
Fig. 24. *H. seversum* Cope, from Oregon; *a*, posterior side.

Note on Hippotherium rectidens. By E. D. Cope.

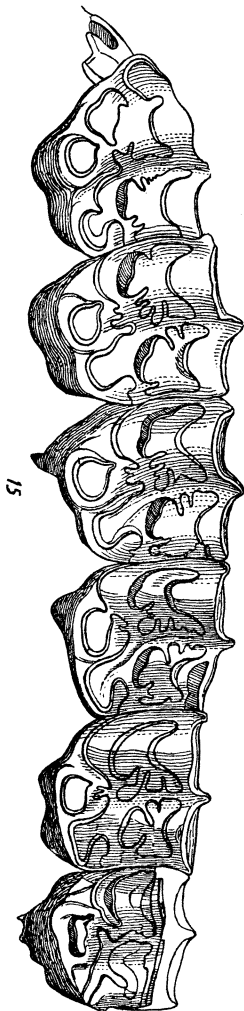
In the preceding monograph of the genus *Hippotherium*, I have stated that the *H. rectidens* Cope is probably founded on a tooth of the *H. montezumæ* Leidy. A renewed examination of the type of the former convinces me that I was premature in reaching this conclusion. Besides the straightness of the crown, the *H. rectidens* possesses a peculiarity not shared by any other species of the genus. The loop, or principal lobe of the lake margins, belongs to the posterior lake, and not to the anterior lake. The latter is its connection in *H. montezumæ*, and in all other species of the genus known to me. It is represented on Plate i, Fig. 3.

HIPPOBOTHRIUM

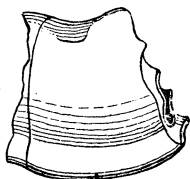




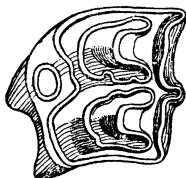
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15



13 a



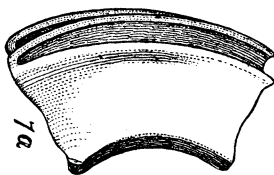
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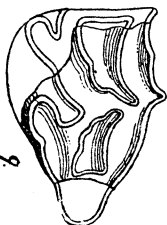
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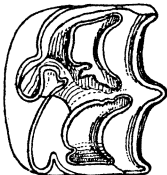
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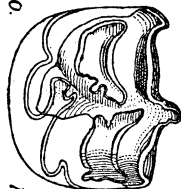
7 a



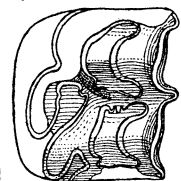
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10.



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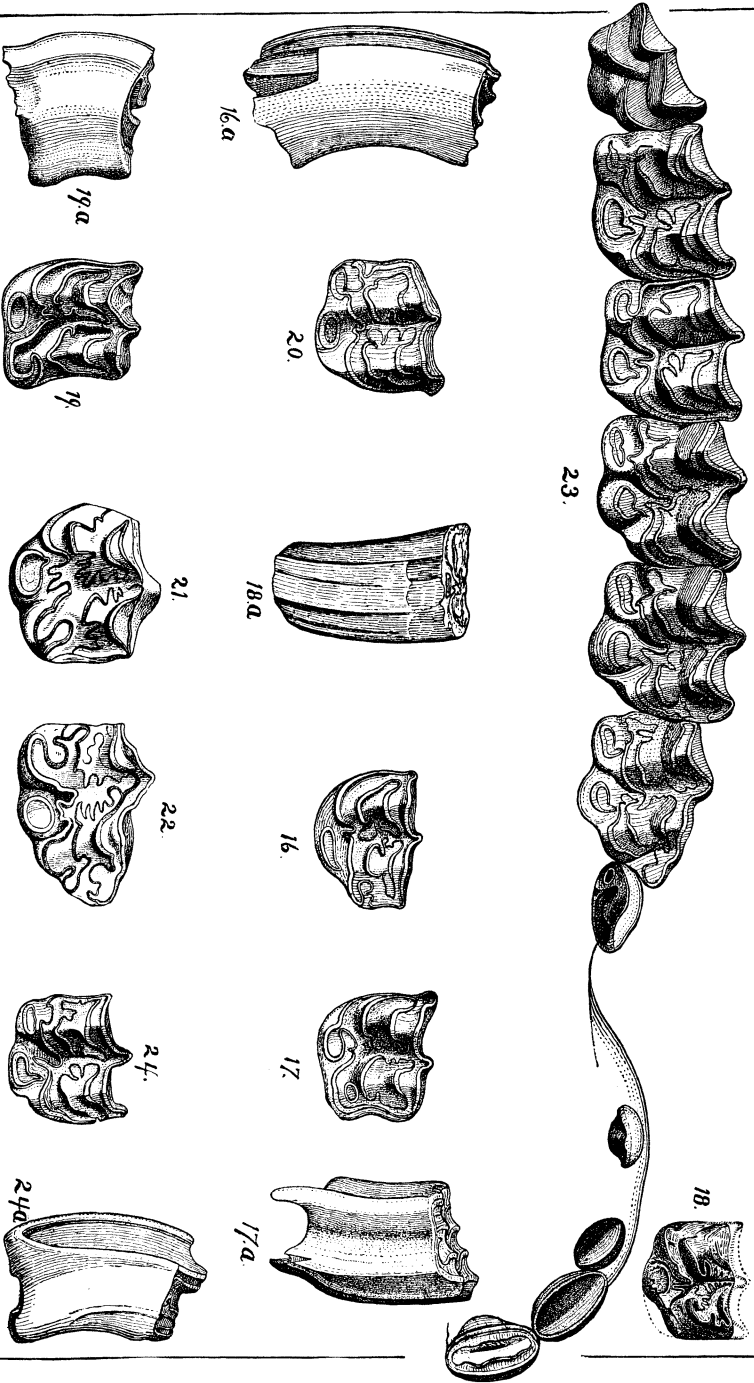
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7.



8.



HIPPOThERium.